to illustrate the point of view that has been developed, which after all is the significant thing in our progress. It would be tedious and unprofitable to enumerate the long list of important new facts that have been discovered. Besides, these new facts are most of them so technical that any brief reference to them would be intelligible only to those who do not need the information. In closing, I may venture to suggest a future development which seems extremely desirable. The general problems upon which we are now engaged must involve the examination of an enormous amount of material before we can feel any confidence in our conclusions. It ought to be possible to associate investigators or laboratories in a general attack upon any problem conceded to be important enough to justify such a united effort. Whenever this has been done in a laboratory possessing several investigators, the result has been striking. We must begin to combine our detached efforts, the guerilla method of attack, and support individual effort by association. The scheme is only a thought, and the details may make it impossible, but I believe that we have reached a point where something of this kind is demanded for definite and substantial progress.

II. The Progress of Plant Anatomy During the Past Decade

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The fascinating problem of the alternation of generations in the higher plants is responsible for the fact that the attention of morphologists, since Hofmeister, has been turned largely to the spore-producing organs and the gametophytes. This tendency can be counted as entirely fortunate, for the closer affinity of the gametophyte with the presumably ancestral forms and the progressive re-

duced and simplified structure, which it presents in the vascular series, has made it particularly suitable for the initial stages of modern morphological development. With the discovery of zoidogamous fertilization in Cycas, Ginkgo and the lower fossil gymnosperms, the revelation of the remarkable mode of fertilization in the Araucarineæ, simulated at least in the Podocarpineæ, the uncovering of the phenomenon of breech fertilization in the lower Amentiferæ and the elucidation of other striking phenomena connected with the male gametophyte, we have come to realize that it is the male sexual generation and the sporogenous apparatus, producing it, which carry the highest phylogenetic interest. The origin of the seed from the megasporangium, although beyond question on general morphological grounds, still largely lacks illuminating facts to lighten the darkness of its past.

The more complicated sporophytic generation of the higher plants, except as to its special sporogenous structures, has much more recently been attacked by evolutionary morphologists. Its very complexity, however, and the possibility of following its structures into the remotest past, make it of the greater importance from the standpoint of the theory of descent. The evidence derived from its study serves, moreover, to control, amplify and enrich the conclusions reached from the standpoint of the morphology of the gametophyte alone. We have, accordingly, begun to realize that the anatomical examination of the sporogenic organs of vascular plants is quite as important as the cytological study of the process of sporogeny itself, and that the fern-like mode of fertilization obtaining in the lower gymnosperms, living and extinct, has its not less important or significant equivalent in the presence of cryptogamic or centripetal primary wood. In fact, with the realization of the importance of the sporophytic generation in the higher plants, we are now for the first time in a position to begin our phylogenetic bookkeeping by double entry, with greatly added security as to the final accuracy of the balance we may strike.

Perhaps nowhere is the advantage of morphological bookkeeping by double entry more clearly illustrated than in the case of the conifers. Forming with the other living gymnospermous species a restricted but illustrious "four hundred," they have quite held their own in botanical interest, in spite of the overwhelming numbers and importance of the modern mob of angiosperms. The older and entirely superficial morphology, led to the conclusion that simple forms and structures are more primitive. On this basis the conclusion was reached that those simple and coneless conifers, the Taxineæ or yews, are the oldest and that the pines or Abietineæ, with their very complicated cone-structures, are most modern. It has, moreover, been inferred that the coniferous tribes represent a series of progression beginning with the yews and ending with the pines. The microscopic study of the gametophytes began the disintegration of this system. The discovery of zoidogamous fertilization in Ginkgo, which in Engler and Prantl's Natürliche Pflanzenfamilien, you will find included with the yews, made it at once apparent that this remarkable genus, sole survivor of an abundant stock, once flourishing through the entire northern hemisphere, could not be included under the Taxineæ, or link the latter with the still more ancient Cordaitales, confined to the Paleozoic. Thus deprived of the reputation of an illustrious ancestry, the yews have since been disrespectfully kicked up the phylogenetic stairs by the younger generation of gametic morphologists. A corresponding but reversed process has in the meantime taken place at the other end of the coniferous series. It has been shown by the gametophytic morphologists, that the sexual generations of the pine tribe are more complicated, and for that reason more primitive in the reduced members of the alternation, than any other conifers, characteristically found in the northern hemisphere. From the sporophytic side it has been shown that the cone-structure of Pinus affords an anatomical explanation of the strobilar organization of the other tribes of conifers on the basis

of commonly accepted principles of reduction and adhesion. Further, it has recently been discovered that the leaves of the ancestral pines (Prepinus) had the same cryptogamic type of centripetal wood-bundles, which are found in the Cordaitales, universally regarded as the Paleozoic stock to which the conifers as a whole are most nearly allied. There is further evidence of the antiquity of the Abietineous or pine tribe based on important experimental data and on the origin of coniferous pitting, which need not be entered upon here. If, in accordance with the facts very briefly indicated above, we cast up our phylogenetic balance by double entry for Pinus, we find it on both sides overwhelmingly in favor of the superior antiquity of the Abietineæ, or pines, as compared with the Taxineæ, or yews. It would take much too long to cast even hastily the balances for the remaining tribes of conifers and in the case of those at present mainly or wholly confined to the southern hemisphere the data are as yet not complete. Even though the books are not yet ready to be opened for the final judgment, the results of recent morphology on both the gametic and sporophytic sides make it clear that the conifers, contrary to the conclusions of the old superficial morphology, are a series of reduction and not one of progression and that their most complicated forms are consequently the oldest and those of simplest guise the most modern.

One of the most striking confirmations of the truth of the theory of organic evolution is found in the recapitulationary phenomena of animals. The colt, for example, in the course of its individual development passes through the phases of progressive loss of digits, presented geologically by the equine stock from the Mesozoic to the present. The young mammal in its earlier stages of ontogeny possesses the gill arches and the segmented musculature of the fish. In the principle of recapitulation presented so clearly in the development of animals, our zoological brethren may fairly claim that on their side of the house the truth of evolution is declared by the

mouths of babes and sucklings. Although our seedlings, unlike the sucklings, are dumb, they are by no means speechless. One of the most striking triumphs of modern plant anatomy is to have discovered many examples of recapitulationary confirmation of the principle of evolution. To take a modern and striking instance, let us consider our common and flourishing northern genus, the oak. You are all familiar with the very broad rays which constitute so ornamental a feature of the structure of oak wood. You are likewise doubtless aware that the weight of paleobotanical evidence speaks for the derivation of the oaks from ancestors resembling the chestnuts since the older oaks approach the chestnuts both in their foliage and in their reproductive organs. The wood of the chestnut differs, however, strikingly from that of oaks by the entire absence of large rays. It has been recently discovered that certain oaks of the gold-gravels (Miocene Tertiary) of California have their large rays composed of aggregations of smaller rays. In the seedlings of certain of our existing American oaks this condition, interestingly enough, is a passing phase, which by the loss of the separating fibers in the congeries of small rays produces the characteristic large rays of the adult. This condition of development in the living oaks is all the more significant because in certain breech-fertilized or chalazogamic amentiferous trees of the present epoch, such as the alder, the hazel and the hornbeam, such aggregated so called false rays are a permanent feature of structure in the adult. From the anatomical side, in the case of the lower Amentiferæ, we have accordingly at the same time an interesting example of the general biological law of recapitulation and a confirmation of the view expressed by Treub and Nawaschin, on evidence from the gametophytic and reproductive side, that the breech-fertilized Amentiferæ are relatively primitive angiosperms.

Perhaps the most valuable service which anatomy is rendering to phylogeny and evolution is in connection

with the elucidation of the affinities of extinct plants. Certain cryptogamic trees of the Paleozoic, the Lepidodendrids, Sigillarians and Calamites, were, for example, long regarded by competent botanists as seed plants on account of their arboreal habit. The anatomists stoutly maintained, however, that from the structure of their primary wood they must be cryptogams. The subsequent discovery of their reproductive structures entirely confirmed the anatomical view. More recently from the study of the anatomy of certain fern-like plants with secondary growth, from the Paleozoic, English and German anatomists reached the conclusion that they were gymnosperms and allied at once to the ferns and to the cycads. Within the past decade, the brilliant discoveries of Oliver, Scott, Kidston, Grand'Eury and David White in regard to the nature of the reproductive organs of these plants, prophetically dubbed by Potonie, the Cycadofilices, have confirmed the truth of the anatomical view as to their affinities in every particular. Let us take a still more modern instance. There are present in the later Mesozoic strata huge quantities of impressions of the cones and leafy twigs of conifers. These have been referred on features of superficial resemblance to a number of genera of living conifers as well as to others not represented in the existing flora. Since they are very numerous, let us take one typical example, which is at the same time significant. Many species of Sequoia have been described from the upper Jurassic and the Cretaceous beds, on the evidence of the impress upon the stony or argillaceous matrix of their cones and leafy branches. Dr. Arthur Hollick and the present speaker have been fortunate enough to secure by new methods of isolation, material of these cones and twigs, with internal structure preserved. The anatomical features of both reproductive and vegetative organs of the remains in question, show beyond any possible doubt that they belong to a tribe of conifers at present confined to the southern hemisphere, the Norfolk Island and Kauri Pines

or Araucarineæ, and have not even the slightest affinity with the living genus, which externally they so strikingly simulate. The reference of the fossil genus just described to its true affinities as well as similar results in the case of a large number of other Mesozoic conifers, likewise erroneously placed in the system, leads to important general conclusions in regard to the evolutionary history of coniferous gymnosperms, which are too lengthy and too technical even to be mentioned here.

But it is not only in connection with extinct plants that anatomy has shown itself the useful servant of phylogeny. The enforced use of anatomical criteria in the case of fossil forms, where such evidence is absolutely indispensable, has resulted in a new and broader point of view in general botanical morphology. Within the decade we have begun to realize fully the great constancy of fibrovascular structures. This may perhaps be best exemplified by a special case. Superficially there is no organ of the plant more prone to vary extremely, within near lines of affinity, than the leaf. If, however, we look within, it presents anatomical features of great constancy. In the case of the leaf, perhaps the most hopelessly variable feature is its size. Anatomically, however, there are just two sizes of leaves, large leaves (megaphylls) and small leaves (microphylls), which are absolutely characterized by their anatomical relations. The foliar strands of the megaphyll, or large leaf, pass off from the woody cylinder of the stem, leaving corresponding gaps in its wall. Those of the microphyll, or small leaf, equally constantly leave no such gaps in their exit from the woody cylinder. It is even possible to divide the whole vascular series into two clean-cut phyla on the basis of the anatomical features of leaf size, viz., the Pteropsida with, anatomically speaking, large leaves, including the ferns, gymnosperms and angiosperms and the Lycopsida, structurally speaking, small leaved forms including among living plants only the club-mosses and horsetails.

I have tried to show above, with all necessary brevity, that the services of anatomy to phylogeny and the doctrine of descent during the past decade have been neither few nor unimportant. Perhaps the most important general result of recent work in the modern morphological field, not restricting it, of course, to anatomy, may best be expressed in the words of the eloquent and philosophical apostle to the gentiles, viz., that the things seen are temporal, while the things unseen are eternal. You may think that I have too much emphasized the importance of internal morphology. One example will serve to show that I have not. You are all familiar with that great German work on the morphology (or, as its author prefers to call it, the organography) of the higher plants, which not very long ago appeared in a *traduction de luxe* from the Oxford University Press. If you scan it from cover to cover, I do not believe you will find a single figure of the fibro-vascular structures. Not even the proverbial halfpenny's worth of bread is present to qualify the oceans of sack. It is not surprising that we should hear from such a source a strong note of morphological pessimism. On a recent occasion in our own country, the distinguished author of the work in question compared the task of his science to that of Sysiphus, of classic fable, condemned to roll up the mountainside a stone which continually rebounds. We may confidently expect that the morphology of the future, distrusting the superficial anfracutosities of the steep, will bring the profitless rolling stone to rest in the very heart of the mountain itself.